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# A new approach for source apportionment of Black Carbon from Raman Spectroscopy

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Keywords: fossil fuel, biomass burning, machine learning

Associated conference topics: 2.7, 2.8, 3.8

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Black Carbon (BC) is a major contributor to air pollution and climate change. Furthermore, it deposits in snow and ice, diminishing their reflectivity and accelerating melting processes. Additionally, BC harms human health, leading to respiratory and cardiovascular issues.

BC can be measured using a variety of techniques including aethalometers, BC analyser or filter-based filtering followed by optical absorption or thermal methods. At present, the most reliable way to perform BC source apportionment is using an Aethalometer employing different wavelengths. This allows for differentiation only between biomass burning and fossil fuel combustion aerosols. However, the accuracy of this model is sensitive to the assumed absorption Ångström exponent values for these sources. Additionally, the model's performance can be affected by the morphology and mixing state of BC, with partially-coated BC potentially leading to significant deviations in biomass burning fraction.

A new way to perform and improve BC source apportionment can be provided by Raman spectroscopy. In a previous work, Drudi *et al* (2023) found, in very polluted region in northern Italy, that at least 50% of the particles analysed in all the $PM_{10}$ sampling contained BC.

Based on these findings, the study aims to further examine BC and its emission sources. To enhance the BC classification specifically for fossil fuel combustion, three categories of BC emission sources have been considered: diesel and gasoline vehicle engines and biomass burning (Figure 1). Instead, PM samples are collected from five separate air quality stations, which have already been described in detail in Drudi *et al* (2023).

The BC and aerosol PM particles were analyzed using a Renishaw inVia Raman spectrophotometer coupled with a LEICA confocal microscope. Measurements were performed using a 532 nm diode pumped solid state (DPSS) laser.

The collected spectra were processed, including screening, smoothing, baseline removal, and deconvolution. The deconvolution used five bands, as proposed by Sadezky *et al* (2005), which provided the features characterizing each spectrum.

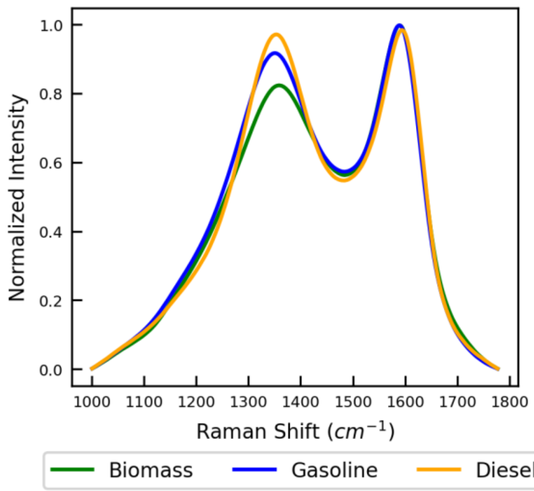


Figure 1. Mean Raman spectra of the BC sources

Statistical and machine learning techniques have been applied to identify data patterns and carry out predictive analysis on PM samples. A range of algorithms can be implemented to identify the optimal method for BC source apportionment, factoring in the differences in measurement acquisition from the BC sources versus the current state of the PM filter. Preliminary results show that K Nearest Neighbours as well as Neural Networks achieve accuracy larger than 95% on the test dataset.

Due to the climate and health effects of BC, providing a method to classify and investigate the source of atmospheric BC aerosol can be useful for obtaining effective information and applying meaningful air quality management. Raman spectroscopy and statistical and machine learning techniques show promising results for the BC source apportionment and can identify the different percentages, not only from biomass and fossil fuel emission but also distinguish from diesel and gasoline.

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